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Association of metabolic syndrome with oral and systemic conditions in morbidly obese patients

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Aim: This study aimed to evaluate oral and systemic conditions in morbidly obese patients with and without metabolic syndrome (MS) prior to bariatric surgery. **Methods:** One hundred patients were included and equally divided into two groups: G1 - with MS (n = 50) and G2 - without MS (n = 50). MS was diagnosed in patients presenting at least three of five signs: abdominal obesity, high triglyceride level, low high-density lipoprotein cholesterol (HDL-C) level, hypertension, and altered fasting glycemia. Variables analyzed included the patients' age, sex, body mass index (BMI), waist-to-hip ratio (WHR), and number of missing teeth. Both BMI and WHR were used to evaluate the risk of developing cardiovascular disease (RCVD). Mann-Whitney, Chi-squared, t test, hierarchical multiple linear regression and binary logistic regression models were used in statistical analyses ($p<0.05$). **Results:** There were no group-wise differences in sex ($p=0.631$) and BMI ($p=0.200$); however, the WHR ($p=0.009$), age ($p=0.0001$), and number of missing teeth ($p=0.0003$) were higher in G1. Obese patients with MS who were candidates for bariatric surgery presented higher RCVD than obese patients without MS ($p=0.019$). Binary logistic regression revealed patient age [adjusted OR=1.05, 95% CI=1.00-1.11, $p=0.042$] and number of missing teeth [adjusted OR=1.17, 95% CI=1.04-1.31, $p=0.013$] to be significant predictors of MS. **Conclusion:** Morbidly obese patients with MS had worse oral and systemic conditions than those without MS, regarding WHR, RCDV and number of missing teeth.

Keywords: Obesity. Metabolic syndrome. Tooth loss. Cardiovascular diseases.

Introduction

The association of low energy expenditure with intake of high caloric diet may contribute to the increase in the prevalence of obesity, a chronic disease characterized by excessive accumulation of body fat[1] and BMI value of ≥ 30.0 kg/m².

The increasing rate of obesity has been considered alarming, since it has strong association with several non-infectious chronic diseases, such as obstructive sleep apnea, type II diabetes, atherosclerosis, and hypertension[2]. In addition, metabolic syndrome (MS) occurs as a consequence of obesity[3] and is originally known as X syndrome which is diagnosed in patients with at least three of the following five conditions: Abdominal obesity indicated by an increase in the waist circumference or BMI index, high triglycerides level, low high-density lipoprotein cholesterol (HDL-C) level, and altered fasting glycemia.

Reports have indicated that due to inflammatory mediators secreted by adipose tissue, patients with obesity can show oral alteration, such as periodontal disease and also the tooth loss[4]. On the other hand, the oral alterations that lead to worsened masticatory function and consequent weight gain are etiological factors of obesity[5].

In case of the tooth loss, there is decreased capacity of food trituration and impaired masticatory function. Progressive loss of the dental elements may alter the patients' nutritional status due to tendency to select foods there are easily chewed. Hence, patients with the tooth loss start consuming larger amounts of saturated fat, fatty acids, and cholesterol. In contrast, the intake of poly-unsaturated fat, fibers, carotene, vitamin C, vitamin E, vitamin B6, potassium phosphate, vegetables and fruits are reduced[6,7]. Therefore, edentulous patients (partial or total) may present impaired masticatory function as the initial stage of digestion which can impair food absorption. Inadequate feeding habit can cause obesity and damages to systemic health.

It is not yet known whether there is an association between oral impairment and presence of MS in patients with morbid obesity. Therefore, the aim of this study was to evaluate tooth loss and systemic conditions in morbidly obese patients with MS recommended to undergo bariatric surgery in the Brazilian public healthcare system. The null hypothesis was that these patients do not show systemic and oral alterations compared to morbidly obese patients without MS.

METHODS

This cross-sectional study followed the STROBE guidelines for correct reporting[8].

Ethical aspect

Per Declaration of Helsinki guideline, this study was conducted under approval by the Ethics Committee on Human Research of the Bauru School of Dentistry, University of São Paulo (process 014/2011). All subjects provided written consent before participation in the study.

Sample composition

The sample was divided into two groups: G1 - 50 patients with morbid obesity and MS; and G2 - 50 patients with morbid obesity without MS.

Eligibility criteria were patients receiving regular medical care before bariatric surgery, with stable systemic health condition (without neurological dysfunction that could stop dental appointments). Exclusion criteria were patients who presented neurological weakness; smoking/drug/alcohol habits, systemic impairments that demanded absolute rest, or were using medications that could harm oral health were excluded. All included patients were < 55 years-old, in order to avoid bias regarding evaluation of the tooth loss in elderly patients.

Systemic health assessment

In each patient, BMI was calculated by dividing the subject's body weight (kg) by height squared (m^2). Weight was obtained using an automatic scale (MIC model 300PP, Micheletti Ind., 300-kg maximum capacity, São Paulo/SP, Brazil), and height with a stadiometer (Wood 2.20, WCS Ind., Curitiba/PR, Brazil) available at Bauru School of Dentistry. Subjects were classified with morbid obesity at BMI ≥ 40.0 kg/m^2, according to the guideline of World Health Organization (WHO)[1].

Moreover, the waist-to-hip ratio (WHR) was calculated from the division of the waist circumference by the hip circumference measured using an anthropometric tape (TEKLIFE, TL200, WISO Ind., São José/SC, Brazil). Per anthropometric standardization reference protocol[9], the patients' risk of developing cardiovascular disease (RCVD) was evaluated based on the WHR, age and sex (*Table 1 and 2*).

Table 1. Classification of women's risk of developing cardiovascular disease, considering age and waist-to-hip ratio

Age (y)	Low	Moderate	High	Very high
20-29	< 0.71	0.71 – 0.77	0.78 – 0.82	> 0.82
30-39	< 0.72	0.72 – 0.78	0.79 – 0.84	> 0.84
40-49	< 0.73	0.73 – 0.79	0.80 – 0.87	> 0.87
50-59	< 0.74	0.74 – 0.81	0.82 – 0.88	> 0.88
60-69	< 0.76	0.76 – 0.83	0.84 – 0.90	> 0.90

Table 2. Classification of men's risk of developing cardiovascular disease, considering age and wait-to-hip ratio

Age (y)	Low	Moderate	High	Very high
20-29	< 0.83	0.83 – 0.88	0.89 – 0.94	> 0.94
30-39	< 0.84	0.84 – 0.91	0.92 – 0.96	> 0.96
40-49	< 0.88	0.88 – 0.95	0.96 – 1.00	> 1.00
50-59	< 0.90	0.90 – 0.96	0.97 – 1.02	> 1.02
60-69	< 0.91	0.91 – 0.98	0.99 – 1.03	> 1.03

Metabolic Syndrome

The most widely used diagnosis guideline of MS is established by the Adult Treatment Panel III (NCEP – ATPIII) of National Cholesterol Education Program (*Table 3*)[10]. In this study, to identify MS, data were obtained from the patients' medical records at Amaral Carvalho Hospital. Subjects presenting at least three risk factors were diagnosed with MS. The following identification criteria and respective limit values were adopted:

In patients of both groups, each risk criterion was registered as 0, absent and 1, present. MS was classified as 0, absent or 1, present, if the patients presented at least three of five characteristics.

Oral Evaluation

Oral examinations regarding missing teeth were conducted by only one previously calibrated dentist (Kappa=0.98). A plain oral mirror, clinical probe n. 05, and syringe with compressed air were used to examine the oral cavity. Regarding oral health, number of the missing teeth in individuals of both groups was registered.

Statistical analysis

All data were organized in Excel 2016 for Windows 10 (Microsoft Corp., Redmond, Washington, USA). Statistical analysis was performed using IBM Statistical Package for Social Sciences (SPSS) software (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.). For calculation of sample size, we considered power of the test of 80%, at significance level of 5%, and sample ratio of 1:1, according to the average number of the missing teeth. Kolmogorov-Smirnov and Shapiro-Wilk tests were applied to verify normal distribution of the sample. Statistical analysis was performed in two steps: Bivariate analysis followed by regression model. In bivariate analysis, t-test was used to examine normally distributed quantitative variables (age, waist circumference, hip circumference, and waist-hip ratio). Mann-Whitney U test was used to examine non-normally distributed quanti-

Table 3. Criteria for identification of metabolic syndrome

Risk Factors	Values
Abdominal circumference (cm)	
Male	> 102
Female	> 88
Triglycerides level (mg/dL)	
Male and female	≥ 150
Cholesterol level (HDL, mg/dL)	
Male	< 40
Female	< 50
Blood pressure (mmHg)	
Male and female	≥ 130/≥ 85
Increased plasma glucose level (mg/dL)	
Male and female	100-125

tative variables (BMI and number of the missing teeth). Chi-square test was used to examine binomial variables (sex classification). As second step, binary logistic regression by stepwise Backward (likelihood ratio) method was performed in order to determine independent variables related to the presence of MS. Multicollinearity analysis showed that all independent variables presented values of tolerance of > 0.10 and variance inflation factor (VIF) of < 2, indicating that all regression requirements were met. Significance level of 5% was adopted.

RESULTS

Among the 100 morbidly obese patients inserted in the sample, 22% were male individuals (n = 22) and 78% were female individuals (n = 78), nevertheless there was no difference between G1 and G2 regarding sex (p=0.631) (*Table 4*).

The average age in the entire sample was 38.4 years, with 42.12 and 34.82 years in G1 and G2, respectively. There was no intergroups significant difference regarding BMI (p>0.05) With regard to the patients' RCVD, G1 presented higher values as compared to G2 and regarding oral evaluation, G1 presented higher number of missing teeth (p=0.0003) (*Table 4*).

Binary logistic regression by stepwise Backward (likelihood ratio) method (*Table 5*) was performed to identify independent variables related to the presence of MS. The analysis achieved statistically significant model [$X^2(2)=24.11$; $p<0.0001$; R^2 of Nagelkerke=0.286] with the following independent variables: patients' age and number of the missing teeth. Overall percentage accuracy of the final model was 73%. Hosmer and Lemeshow analysis indicated chi-square value in the final model of 4.75 for 8 degrees of freedom (p=0.784). Patients' age [adjusted OR=1.05, 95% CI=1.00-1.11, p=0.042] and number of the missing teeth [adjusted OR=1.17, 95% CI=1.04-1.31, p=0.013] were significant predictors of the presence of MS.

Table 4. Comparison of variables between groups

	G1 (n=50)	G2 (n=50)	p
Age (y)	42.12 ± 10.42	34.82 ± 7.85	0.0001*
Waist circumference (cm)	132.86 ± 13.00	126.72 ± 17.53	0.049*
Hip circumference (cm)	145.68 ± 15.76	146.32 ± 15.62	0.838*
WHR	0.92 ± 0.09	0.86 ± 0.09	0.009*
BMI (kg/m²)	52.39 [46.02-59.00]	50.62 [45.00-56.00]	0.200†
Patients' RCVD	4 [3-4]	3 [2-4]	0.019†
Number of the missing teeth	4 [0-11]	1 [0-2]	0.0003†
Sex			
Male	12	10	0.631‡
Female	38	40	
RCVD			
Low/Moderate	11	23	0.011‡
High/Very High	39	27	

* t test / † Mann-Whitney test / ‡ Chi-squared test

Table 5. Final model of binary logistic regression related to the presence of MS

Coefficient[a]						
	B	Wald	df	p	Adjusted OR	95% CI
Constant	-2.66	6.79	1	0.009	0.07	
Age	0.05	4.13	1	0.042	1.05	1.00-1.11
Number of the missing teeth	0.15	6.13	1	0.013	1.17	1.04-1.31

[a] Outcome: Number of the missing teeth; B: coefficient; df: degree of freedom; p: significance level; OR: Odds Ratio; CI: Confidence Interval

DISCUSSION

This study investigated the association between obesity, MS, and the tooth loss which adds to the information previously reported. The results indicated that patients with obesity and MS who are candidates for bariatric surgery presented higher number of the missing teeth and higher RCVD than those without MS. Therefore, the study's null hypothesis is rejected.

Obesity is one of the most neglected health problems worldwide. MS, another condition related to obesity, is characterized by the presence of a set of metabolic and hemodynamic changes in the body which may include insulin resistance, hyperinsulinemia, hypertension, increased VLDL-cholesterol level, increased triglycerides level, decreased high density lipoprotein (HDL) level, abdominal obesity, microalbuminuria, and hypercoagulation[10].

In this study, there was no intergroups difference regarding sex (*Table 5*), but both groups presented higher number of female patients. It may be explained by the fact that women are more prone to seek treatment for obesity under social media conditioning regarding the body image[11]. There was difference between G1 and G2 regarding the patients' age; however, the standard deviations of both groups showed that this difference was not relevant when considering analysis of the tooth loss. All included patients were < 55 years-old.

Reports have indicated that in the evaluation of abdominal obesity, WHR is the best indicator of myocardial infarction[12]. Patients with morbid obesity and MS presented median BMI of 52.39 kg/m² and mean WHR of 0.92, whereas those without MS had median BMI of 50.62 kg/m² and mean WHR of 0.86 (*Table 5*). Therefore, G1 showed higher RCVD, in agreement with previous studies[13,14]. This finding can be explained based on association of *in vivo* metabolic and inflammatory changes in these patients.

Studies focused on the relationship of obesity to several problems in the oral cavity have been reported. For instance, association between dental caries and obesity is still inconclusive[5,15,16]. However, the association between obesity and periodontal disease is well established; release of pro-inflammatory cytokines by the adipose tissue may affect the patients' periodontal condition[17,18]. This association is relevant to public health, once both are associated factors for cardiovascular diseases[18,19]. Moreover, at advanced stages, periodontal disease is able to cause the tooth loss which can compromise the patients' nutritional status, resulting in systemic disorders. Studies have shown that lack of the teeth seriously compromises the patients'

well-being, as it reduces the masticatory function, causing difficulties in the intake of nutritional food[20,21].

In this study, morbidly obese patients with MS had higher number of the missing teeth and, consequently, lower masticatory function as compared to morbidly obese patients without MS (p=0.0003) (*Table 5*). This result could be explained by the patients' eating habits. People with reduced masticatory function swallow larger pieces of food and consume industrialized soft foods with high fat and caloric content. The tooth loss may change the patients' chewing ability, which can lead to impaired nutrition intake and consequently, systemic disorders[22]. Therefore, it is important to ensure prosthodontic rehabilitation of the patients in order to avoid systemic disfunctions.

The final model of binary logistic regression revealed the age and number of missing teeth (OR=1.17; p=0.013) as predictive factors of MS (*Table 6*). Scientific literature is not consistent regarding the role of MS in the occurrence of tooth loss or vice-versa. The association between the number of the teeth and MS may be bi-directional[23]. In agreement with our study, many other studies reported association between presence of MS and the tooth loss[24-26]. On the other hand, Furuta et al.[27] highlighted that middle-aged people with MS had an increased risk of the tooth loss compared to individuals without MS. Zhu and Hollis[28] reported that MS may be a risk factor for the tooth loss in middle-aged individuals.

Nevertheless, the cross-sectional model of this study does not enable conclusion regarding directional association between the tooth loss and presence of MS.

Our study has some limitations. Considering the relationship between genetic factors and MS reported in many studies, for better understanding regarding MS and oral condition, future studies with adequate methodology are required. Longitudinal research with higher sample number should be performed in order to determine the relationships of variables. Moreover, although we could determine abnormality related to the levels of triglycerides, cholesterol, blood pressure, and plasma glucose, we were unable to obtain respective numerical values from the patients' medical files.

Nevertheless, this study is important since few studies focusing on the association between obesity, MS, and the tooth loss have been conducted in Brazil. Moreover, patients with these alterations must be assisted by a dentistry team in order to ensure nutritional and, consequently, systemic health.

In conclusion, when MS is associated with obesity, the risks of developing cardiovascular diseases increase in morbidly obese patients. In addition, patients with morbid obesity and MS present higher number of the missing teeth than obese patients without MS, which impairs their masticatory function.

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